REAL Centre's Assessment of the model underlying the NHS England's Long-Term Workforce Plan

February 22, 2023

Introduction

In February 2023, the Health Foundation's REAL Centre was approached by NHS England to assess the model underlying the Long-Term Workforce Plan (LTWP). Within the limited time available before anticipated publication of the LTWP, it was agreed that the REAL Centre would focus on assessing the process underlying NHS England's long term workforce modelling. This assessment was completed based on the model documentation provided to us as of February 14, and submitted to NHS England on February 22, 2023.

The REAL Centre's framework for assessment of the modelling approach underlying the LTWP is built on the Code of Practice for Statistics[1]. We reviewed all the questions under the 'Quality' and 'Value' domains ('pillars') of the code, and selected questions relevant for our assessment. For example, we excluded 'Q3: Assured quality' from our framework of assessment because we are not conducting a full quality assurance of the model. These are set out in the Annex A of this document. As part of this assessment, the REAL Centre was given access to a range of model documentation and outputs that are listed in the technical Annex accompanying this letter. As such, the assessment does not include a full review of the LTWP model, its structure, approach, set-up of modelling, inputs, outputs, assumptions and scale of impact/ results, i.e., this does not mean that the Health Foundation endorses the projections themselves.

Overview of Model Assessment

As part of our data sharing agreement with NHS England, we received documentation on the methods for various components of the model, log of assumptions and quality assurance documentation. Where we identified the need for further evidence or justification for decisions taken, we requested additional documentation. A full list of documents used in our assessment are set out in our documents log in Annex C. We also participated in six workshops on various components of the model with colleagues from NHS England to provide further clarity on the materials shared with us, which are also set out in Annex D of this document.

Using our assessment framework and the documentation provided we have produced a table outlining our overall assessment in response to specific questions in each domain (see Annex B). In our assessment we have been able to validate some of the processes undertaken in developing the model, but not all. A summary of the key points from our assessment are listed below:

- The data underlying the model is drawn from relatively data rich administrative resources which allows for analysis at a level of granularity that other models are not able to do.

[1] https://code.statisticsauthority.gov.uk/the-code/

- There is variation in quality of documentation provided to us on different components of the model. The model components draw on several other models which have complex interlinkages. In some cases, the documentation reflects good practice and provides clear rationale for decisions whereas in other cases there is scope for improvement for transparency.

- Some underlying uncertainties in the model are not adequately documented. Modelling uncertainty comes from three main sources: (1) data uncertainty, (2) parameter uncertainty, and (3) model or epistemic uncertainty[2]. In most cases, parameter uncertainty and data uncertainty has been well documented and considered. Based on the information shared with us, we cannot determine whether epistemic uncertainty has been considered at all.

- In the modelling of interventions, there is limited documentation on how decisions were taken about which parameter values to use.

- For a comprehensive consideration of possible scenarios, modelled interventions should also present "downside" risks of assumptions not materialising as many of these assumptions are highly uncertain.

- There is commitment to an ongoing process of model review and improvement, which is important for continued relevance and sustainability of the overall approach. This process should also be transparent, in order to enable independent review. Our current assessment can be taken as an early exemplar of this potentially dynamic process.

Our overall conclusion, based on our assessment, is that the data sources and methods used in the model are appropriate and the assumptions used to develop the baseline models are plausible. The modelling of interventions is subject to greater uncertainty due to lack of complete documentation. However, within the constraints of time and available material, we were not able to assess whether the best modelling approach has been adopted and whether relevant external stakeholders have been engaged throughout the process of model development.

Key modelling risks

The modelling assumptions on "productivity" in the interventions pose a key risk, as evidence about the potential of these productivity improvements being fully realised is limited. As noted above, the development of a further "downside" scenario should be considered, in order to demonstrate the case if these productivity gains are not realised to plan for contingencies.

Another area of risk that we identify is the lack of consideration and documentation on model selection. For example, pay and wider labour market dynamics have not been considered in the baseline model for the supply workforce modelling. There is evidence available which suggests that these are key factors in determining whether individuals seek to join and stay in the NHS workforce, particularly for non-clinical professions and occupations. The rationale for inclusion and exclusion of variables from the model should be clearly set out.

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[2] Data uncertainty reflects the uncertainty from measurement error or inherent noise in the data. Parameter uncertainty reflects the uncertainty in parameter estimates used in the model, which can be driven by sampling variation, surrogate data etc. Model or epistemic uncertainty comes from model selection and structure imposed on that data.

A further risk stems from the fact that this model draws on outputs from several other underlying models. Clearer documentation on how all the underlying models link into the main model will be helpful in ensuring model coherence and clearly identifying the interdependencies between the various components of the model. This will allow for appropriate consideration of interlinkages between variables across components in future updates to the model.

Annex A – Framework for Assessment

Table A1: Questions of relevance for the REAL Centre's verification assessment

Domain/ Question in the Code of Practice for Statistics	Conversion into a directly relevant question for the current assessment
Quality: Q1: Suitable data sources	
Q1.1 Statistics should be based on data sources that are appropriate for the intended uses. The data sources should be based on definitions and concepts that are suitable approximations of what the statistics aim to measure, or that can be processed to become suitable for producing the statistics.	Are the data sources underlying the modelling appropriate in light of what the modelling aims to capture? Were alternative data sources considered and are the reasons for their not having been used made clear?
Q1.5 The nature of data sources, and how and why they were selected, should be explained. Potential bias, uncertainty and possible distortive effects in the source data should be identified and the extent of any impact on the statistics should be clearly reported.	Is there clarity and transparency around the process of selection of data sources underlying the modelling? Were alternatives considered with a view to identifying potential bias, uncertainty and possible distortive effects in the source data?
Q1.7 The impact of changes in the circumstances and context of a data source on the statistics over time should be evaluated. Reasons for any lack of consistency and related implications for use should be clearly explained to users.	Is there a transparent record of how changes in the circumstances and context of data sources over time might affect the modelling? Are any relevant assumptions or caveats around future changes in the source data and the implications for future use of these data clearly explained?
Quality: Q2: Sound methods	
Q2.1 Methods and processes should be based on national or international good practice, scientific principles, or established professional consensus.	Is it clear that the modelling methodology is based on national or international good practice, scientific principles, or established professional consensus?
Q2.3 Statistics producers should be transparent about methods used, giving the reasons for their selection. The level of detail of the explanation should be proportionate to the complexity of the methods chosen and reflect the needs of different types of users and uses.	Is there evidence of a rigorous process underlying the selection of the methodology and processes used in the modelling? Is there a transparent record of how the model scenarios and their underlying assumptions were agreed upon?
Q2.4 Relevant limitations arising from the methods and their application, including bias and uncertainty, should be identified and explained to users. An indication of their likely scale and the steps taken to reduce their impact on the statistics should be included in the explanation.	Are the limitations of the modelling methodology, including bias and uncertainty, clearly explained? Is there a transparent log of possible risks, mitigation strategies, sensitivity analysis, and the implications of interlinkages between the different analytical models that feed into the modelling?
Value: V3: Clarity and insight	
V3.1 Statistics, data and explanatory material should be relevant and presented in a clear, unambiguous way that supports and promotes use by all types of users.	Are the results of the modelling presented and explained in a clear, transparent and unambiguous manner? Are they described in non-technical language which could reasonably be understood by interested parties who do not have expertise in modelling?
V3.3 Comparisons that support the appropriate interpretation of the statistics, including within the UK and internationally, should be provided where useful. Users should be signposted to other related statistics and data sources and the extent of	Are appropriate comparisons presented to support the appropriate interpretation of the results of the modelling, including within the UK and internationally? Is there a log of the

consistency and comparability with these sources should be explained to users.	process underlying decisions around the use of such comparisons?
Value: V4: Innovation and improvement	
V4.1 Statistics producers should keep up to date with developments that can improve statistics and data. They should be transparent in conducting their development activities, and be open about the outcomes and longer-term development plans. *AND* V4.5 Statistics producers should keep up to date with developments that might improve methods and quality. They should assess the added value of potential improvements and consider the likely impact on the statistics, including in relation to comparability and coherence.	Is there an unambiguous commitment to future iterations of the long term workforce plan, with the aim of developing and improving the underlying data sources and methods?
V4.4 Statistics producers should seek to collaborate with other producers, including within the UK and internationally, when developing their statistics, overcoming practical obstacles, and sharing best practice.	Are the outputs of the modelling transparent regarding existing stakeholder consultation and any future plans to engage with new stakeholders, including within the UK and internationally, on data sources, methodology and outputs?

Annex B – Assessment Matrix

Quality: Q1: Suitable data sources	**Q1.1**	Statistics should be based on data sources that are appropriate for the intended uses. The data sources should be based on definitions and concepts that are suitable approximations of what the statistics aim to measure, or that can be processed to become suitable for producing the statistics.
		Are the data sources underlying the modelling appropriate in light of what the modelling aims to capture? Were alternative data sources considered and are the reasons for their not having been used made clear?
What we were able to assess		That the model uses a range of appropriate data sources to capture projections of the NHS workforce supply and demand, each assessed for whether it is fit for purpose. That the datasets selected for data transformation and those feeding the model inputs are suitable for producing the statistics.
What we were not able to assess		Whether there was a systematic approach taken to determine whether data sources were assessed for suitability/fit for purpose. Whether alternative data sources were considered for all data sources and if so, their reasons for not having been used. Where data sources have been recorded as not available or of limited utility, and data was sourced through extrapolation of historic trends, the extent of consultations with relevant stakeholders/clinical input and programme leads
Documents/evidence provided		• NSHEI Critical Model QA Review Framework • BAU Workforce Activity Model • Assumptions log • Workforce Modelling Technical Guide • LTWP Supply Modelling – medical components (consultants) • Understanding Analysing and Projecting Medical Workforce • HEFT Handbook • HERMES Handbook
Scope for improvement		Clear documentation outlining the process of assessment for suitability and fit-for-purpose of data sources. Documented consideration of other data sources and consistent justification of the appropriateness of selected data sources. Systematic and shared documentation of the decisions made internally.
Risks		That due to the data being primary sourced data, there is a lack of external validation/triangulation of the data sources.

Quality: Q1: Suitable data sources	**Q1.5**	Q1.5 The nature of data sources, and how and why they were selected, should be explained. Potential bias, uncertainty and possible distortive effects in the source data should be identified and the extent of any impact on the statistics should be clearly reported.
		Q1.5 Is there clarity and transparency around the process of selection of data sources underlying the modelling? Were alternatives considered with a view to identifying potential bias, uncertainty and possible distortive effects in the source data?
What we were able to assess		Some data sources were assessed against the six dimensions of data quality: completeness, uniqueness, accuracy, validity, timeliness, consistency and fit for purpose. All data inputs/variables and assumptions were quality rated and assessed for data quality, underlying modelling, and level of uncertainty. Some model inputs have a clear and transparent record of their data source selection process, as well as the consideration of alternatives to identify bias, uncertainty and possible distortive effects (i.e., medical workforce supply, retention, and leaver rates HIA, and some assumptions). Where data sources have been recorded as not available or of limited utility, there has been transparency around the selection of data through extrapolation of historic trends, consultations with relevant stakeholders/clinical input and programme leads.
What we were not able to assess		Whether there was a recorded assessment of each data source against the data quality dimensions and if this formed part of the process of data selection. Unless separate to the descriptions of the inputs/variables and assumptions underlying the model, there does not appear to be a documented process of how data was selected. Whether alternatives were considered for all data sources. Whether the process of data selection has been clear and transparent where the data source for assumptions and their methodology has referenced internally held documents or discussions.
Documents/evidence provided		• NSHEI Critical Model QA Review Framework • BAU Workforce Activity Model • Assumptions log • HIA Assumptions log • Workforce Modelling Technical Guide • Change log • Understanding Analysing and Projecting Medical Workforce • HEFT Handbook • HERMES Handbook
Scope for improvement		Clear documentation outlining the process of data selection and whether the data quality dimensions formed part of this process. Full transparency where internally held documents or discussions have been incorporated as data sources underlying inputs and assumptions within the model.
Risks		That comprehensive external quality assurance of the model cannot be carried out due to the individual elements of the model being developed separately.

Quality: Q1: Suitable data sources	**Q1.7**	The impact of changes in the circumstances and context of a data source on the statistics over time should be evaluated. Reasons for any lack of consistency and related implications for use should be clearly explained to users
		Is there a transparent record of how changes in the circumstances and context of data sources over time might affect the modelling? Are any relevant assumptions or caveats around future changes in the source data and the implications for future use of these data clearly explained?
What we were able to assess		There has been a transparent record of changes to the decisions underlying the model and the rationale for the change, though only a subset of these are due to data sources (i.e., funding confirmations, delayed data releases, stakeholder input, separately modelled inputs). That there has been some consideration and transparency in the recording of changing circumstances/context, but this is only available for certain data sources (i.e. the use and adjustments made to 2018/19 PLICS data to account for the Covid-19 pandemic impact and lack of historic data), subsets of the model (i.e. impact of the pandemic on leaver rates, virtual wards scenario modelling, primary care), and certain data inputs and assumption through quality and impact assessments.
What we were not able to assess		Whether there is a complete record of how changes in circumstances and context of data sources might affect the modelling. Whether there is a record of the assumptions or caveats around future changes in the source data and the implications for their future use within the model.
Documents/evidence provided		• Assumptions log • Changes log • LTWP Supply modelling v2 • BAU Workforce Activity Model • HEFT Handbook • Impact Pandemic on Leaver FTE
Scope for improvement		A clear and transparent record of how changes in the circumstance and context of each main data sources might affect the modelling, and updated explanations on future changes in the source data. A consistent and model-wide approach for considering the impact of the pandemic on data.
Risks		That future updates of the model may not account for all interdependencies within the model

Quality: Q2: Sound methods	**Q2.1**	Methods and processes should be based on national or international good practice, scientific principles, or established professional consensus.
		Is it clear that the modelling methodology is based on national or international good practice, scientific principles, or established professional consensus?
What we were able to assess		The documentation underlying the overall modelling approach informed us that various stakeholders were consulted, principally colleagues from within NHS England and HEE.
What we were not able to assess		Whether the methodology selected was based on specific national or international good practice or scientific principles; Whether relevant colleagues outside NHS England and HEE were consulted (e.g. academia, think tanks, international organisations such as OECD and WHO); Whether there was a discussion around modelling any non-linear effects; Whether there was a discussion around modelling any wage elasticities
Documents/evidence provided		• Technical modelling guide • LTWP cancer and diagnostics update • PC LTWP modelling update • HEFT Handbook
Scope for improvement		Input from additional stakeholders (academia, think tanks, WHO, OECD); Consistent approach to documenting the modelling methodology and consideration of best practice/alternatives across the demand and supply projections.
Risks		That the methodology cannot be shown to be underpinned by best practice principles or established consensus. That limited documentation on model conception may impact the clarity surrounding modelling rationale and considerations (e.g., non-linear effects, wage elasticities, wider-labour market dynamics). That future development of the model methodology can adapt to fully consider the range of options based on the availability of better data

Quality: Q2: Sound methods	**Q2.3**	Statistics producers should be transparent about methods used, giving the reasons for their selection. The level of detail of the explanation should be proportionate to the complexity of the methods chosen and reflect the needs of different types of users and uses.
		Is there evidence of a rigorous process underlying the selection of the methodology and processes used in the modelling? Is there a transparent record of how the model scenarios and their underlying assumptions were agreed upon?
What we were able to assess		The documentation provided informed us that various stakeholders were consulted, principally colleagues from within NHS England and HEE for the purposes of methodology development. Some assumptions seem to be well justified. For example, the assumptions log notes that the assumption of a 'starting' supply-demand gap for FTE GPs is based on the REAL Centre's 2022 NHS workforce projections analysis.
What we were not able to assess		The process underlying the selection of the modelling methodology is not entirely clear and varies across model components. No transparent record or decision log of why only two principal scenarios were chosen for modelling (the counterfactual and the 'interventions' scenario) Some assumptions do not seem to be well justified. For example, the assumptions log notes that the assumption of the demand for and supply of nurses in general practice being equal between 2021/22 and 2023/24 is based on there being no manifesto commitment for general practice nursing, which seems debatable. Whether there was a process of selection by which assumptions about parameters underpinning the policy scenarios were chosen.
Documents/evidence provided		• Technical modelling guide (mentions stakeholder engagement); • assumptions log (for specific assumptions); • QA review framework (mentions stakeholder engagement) • Change log • HEFT Handbook • LTWP cancer and diagnostics update
Scope for improvement		Clear documentation on the selection process of modelling methodology across all components of the model.
Risks		The absence of a scenario highlighting potential risks or reductions in future supply could be a weakness. It points to the possibility of “optimism bias” having played a role in decision making on the selection of LTWP scenarios. Some of the assumptions underlying the modelling appear to be better justified than others. Where NHS England colleagues have suggested that relevant decisions were taken at internal meetings or discussions, the process had not been fully transparent as they have not been able to provide records or email correspondence to evidence this.

Quality: Q2: Sound methods	**Q2.4**	Relevant limitations arising from the methods and their application, including bias and uncertainty, should be identified and explained to users. An indication of their likely scale and the steps taken to reduce their impact on the statistics should be included in the explanation.
		Are the limitations of the modelling methodology, including bias and uncertainty, clearly explained? Is there a transparent log of possible risks, mitigation strategies, sensitivity analysis, and the implications of interlinkages between the different analytical models that feed into the modelling?
What we were able to assess		Sensitivity analysis was carried out for some key areas of uncertainty, such as productivity recovery, virtual wards and intermediate care, and SAS/LED primary care intervention, but not for others (assumptions on case mix or productivity). 20 – 30 underlying models feed into the outputs of the LTWP model. Presentation slides of key outputs do not reflect any information on underlying epistemic uncertainty
What we were not able to assess		There does not appear to be a record of how the variables or parameters to be used in the sensitivity analysis that was undertaken were determined or agreed upon. Equally, it is unclear whether sensitivity analysis was undertaken only for these variables or also for other variables (but not necessarily documented).
Documents/evidence provided		• NHSEI Critical Model QA review framework • Change log • Uncertainty in LTWP modelling • LTWP cancer and diagnostics update
Scope for improvement		Documentation of all sensitivity analysis across all model components/inputs/assumptions/ variables within a single output. Development of a decision log containing how results from sensitivity analysis have been considered in informing the consideration of interventions and scenarios (i.e., assumptions around productivity). Consideration of ranges for variables and assumptions for robust sensitivity analysis, especially for the estimated productivity rate. Consideration of York estimates or alternative measures.
Risks		The presentation of bias and uncertainty in the results may have shortcomings. In many instances, ranges may be more helpful than point estimates given the long modelling timeframe (to 2036/37). There is a relatively high level of risk rooted in multiple complex interlinkages between underlying models, which appears to have been underemphasised elsewhere in the model documentation and outputs Where NHS England colleagues have suggested that relevant decisions were taken at internal meetings or discussions, the process has not been fully transparent as they have not been able to provide records or email correspondence to evidence this.

Value: V3: Clarity and insight	**V3.1**	Statistics, data and explanatory material should be relevant and presented in a clear, unambiguous way that supports and promotes use by all types of users.
		Are the results of the modelling presented and explained in a clear, transparent and unambiguous manner? Are they described in non-technical language which could reasonably be understood by interested parties who do not have expertise in modelling?
What we were able to assess		That graphical representations of the results and modelling components are clear and transparent and interactive dashboards present numerical information clearly. Some aspects of the modelling and presentation of results have been described in non-technical language for understanding by interested in parties who do not have expertise in modelling.
What we were not able to assess		Whether there is sufficient transparency on why certain scenarios and parameter values were chosen and their impact on the results, as these decisions were taken in meetings with senior officials. Whether results of the modelling and the different scenarios will be described in non-technical language and presented and explained in a clear, transparent and unambiguous manner.
Documents/evidence provided		• CF Modelling Output Comparison • LTWP Supply modelling v2 • General Practice LTWP Modelling • Retention HIA • Workforce Modelling Logic with productivity adjustment • Workforce Modelling Technical Guide
Scope for improvement		A system map that provides an overview of all model components and how they interact. Documentation that pulls together the most important components of the model at a high level for reasonable understanding by interested parties. Detailed and consistent description of the modelling results and different scenarios.
Risks		Without clear documentation on the statistics, data and explanatory material, new users will be unable to interact with the model, risking its continuity and future improvement.

Value: V3: Clarity and insight	**V3.3**	Comparisons that support the appropriate interpretation of the statistics, including within the UK and internationally, should be provided where useful. Users should be signposted to other related statistics and data sources and the extent of consistency and comparability with these sources should be explained to users.
		Are appropriate comparisons presented to support the appropriate interpretation of the results of the modelling, including within the UK and internationally? Is there a log of the process underlying decisions around the use of such comparisons?
What we were able to assess		There is reference to some assessments of how the results compare to other projections within the UK (those produced by the Health Foundation, Edge Health).
What we were not able to assess		Though there is some evidence of comparing the results internationally using OECD data, this is not a like-for-like comparison as the future values of other countries are extrapolated based on historic growth, while the results for the UK are based on the results of the model. Whether there was consideration of the modelling approaches of other health systems, including within the UK and nationally, and how these results compare.
Documents/evidence provided		• LTWP Supply modelling v2 • Uncertainty in in LTWP modelling
Scope for improvement		Appropriate comparisons of the results to support the appropriate interpretation of the results of the modelling, including within the UK and internationally. Documentation on the processes underlying the decisions around choice of comparators and the method of comparison.
Risks		The international comparisons are not considered wholly appropriate for the interpretation of the results as the methodology behind the comparator is different.

Value: V4: Innovation and improvement	**V4.1 AND V4.5**	V4.1 Statistics producers should keep up to date with developments that can improve statistics and data. They should be transparent in conducting their development activities and be open about the outcomes and longer-term development plans.
		V4.5 Statistics producers should keep up to date with developments that might improve methods and quality. They should assess the added value of potential improvements and consider the likely impact on the statistics, including in relation to comparability and coherence.
		Is there an unambiguous commitment to future iterations of the long term workforce plan, with the aim of developing and improving the underlying data sources and methods?
What we were able to assess		There is a commitment for the model to be updated on an annual basis to reflect changes to service demand and evolution of the healthcare system over time. There will be ongoing development/review of the model / consideration of external review
What we were not able to assess		Whether there is a commitment to improve the underlying methods and whether there are mechanisms to incorporate modelling feedback on methodology. Commitments to regular assessments of the data against the data quality dimensions.
Documents/evidence provided		• Methodology workforce modelling narrative v1.0 • NSHEI Critical Model QA Review Framework • HEFT handbook
Scope for improvement		Commitments to include broad stakeholder engagement (i.e., those outside of government) and processes to incorporate their input. Commitments to improve the accessibility of the underlying model documentation and discussions. Commitments to improve consistent model documentation to allow for future development of the model.
Risks		Overly optimistic expectations of the modelled outputs without broad stakeholder involvement in the continued model development.

Value: V4: Innovation and improvement	**V4.4**	Statistics producers should seek to collaborate with other producers, including within the UK and internationally, when developing their statistics, overcoming practical obstacles, and sharing best practice.
		Are the outputs of the modelling transparent regarding existing stakeholder consultation and any future plans to engage with new stakeholders, including within the UK and internationally, on data sources, methodology and outputs?
What we were able to assess		That there has been engagement with external stakeholders on outputs of the modelling.
What we were not able to assess		Whether there are future plans to engage with new and existing stakeholders on data sources, methodology and outputs of the model. Whether there are future plans to improve transparency of data sources, methodology and model outputs for comprehensive stakeholder consultation.
Documents/evidence provided		• NSHEI Critical Model QA Review Framework • Change log
Scope for improvement		Publication of aggregated data would improve transparency and facilitate the external development of models for future comparisons.
Risks		That future model development may be limited without continued development of statistics, stakeholder engagement, and sharing of best practice.

QA process summary:

The LTWP model was originally developed by Carnall Farrar, a consultancy with expertise in health care modelling, in 2021/22 in software called 'pyspark'. Subsequently, NHSE assumed full ownership of the model and subjected it to a quality assurance (QA) process which led to some changes. This QA process followed the Macpherson review guidelines and involved the following steps:

- The model was reviewed and tested by NHS England colleagues who were not a part of the LTWP modelling team.
- The original pyspark model remains the primary model for the LTWP outputs. As part of the QA process, two stages were carried out: firstly, the original pyspark model developed by CF was also developed in an alternative software, 'Alteryx', by NHS England colleagues as a way to test and sense-check changes to the modelling. Secondly, once NHSE assumed full ownership of the model, the LTWP model was later quality assured in pyspark by NHS England colleagues not involved in the LTWP modelling effort to primarily test and verify the model structure, data and assumptions, calculations, and documentation.

- The model was reviewed and tested using the Department for Business, Energy & Industrial Strategy (BEIS) modelling quality assurance tools and guidance.

Annex C - Documentation log

Title of document folder	Description of document contents (date received)
Quality Assurance	Includes: 1. **NHSEI Critical Model QA Review Framework – LTWP_HF review** (10.02.2023) -: completed QA template which outlines the checks and assurance process applied to the model records reviews of: documentation, data, quant evaluation, model and summary. It also records the evidence and other models. 2. **NHSE Model QA Template Workforce** (07.02.2023) –: completed QA template which outlines the checks and assurance process applied to the model records reviews of: documentation, data, quant evaluation, model and summary. It also records the evidence and other models. 3. **Workforce Modelling BEIS Model QA Template** (10.02.2023) –: QA log outlining requirements, rating, current status and outstanding work for model documentation, structure & clarity, verification, validation, and data & assumptions. 4. **Python Code Workforce Planning QA Summary** (10.02.2023): record of the completed quality assurance process of line by line code review and read through of the technical guide and assumptions log.
Model Documentation	Includes: 1. **Workforce Modelling Technical Guide** (07.02.2023): This covers data sources (input files and lookup tables), transformation logs of data sources to outputs, the logic of their use within the model and the development of grouped data sources through graphical presentations of the model. It includes sections on: staff in post, establishment and supply projections; demand modelling for Acute, Ambulance, Community, Mental Health % learning disability, and Primary Care Settings; and Gap analysis. Also included are manual adjustments of the data were required, and within the appendix: technical structures of the demand and supply levers, gap analysis, and acute relative productivity adjustment calculation. 2. **Methodology workforce modelling narrative v1.0** (07.02.2023): Outlines the methodology of the overall gap between workforce demand supply in the NHS over the next 15 years and offers definitions for key terms, timelines and the granularity of the model. 3. **Workforce Modelling Logic w productivity adjustment** (07.02.2023)**:** As above, with the addition of graphical comparisons of the counterfactual and adjusted numbers. 4. **CF modelling output comparison** (10.02.2023): Presents dashboards on the overall workforce gap, by care setting, specialty, and staff group growth, across scenarios and data inputs. 5. **BAU Workforce Activity Model** (07.02.2023): provides an overview of the modelling approach to the Business As Usual (BAE) workforce-activity model for acute care. 6. **LTWP modelling** (07.02.2023): Briefly covers the overall aim, scope and methodology of the workforce model to show reduction of the workforce shortfall from the counterfactual position. It presents the core assumptions made for demand, productivity and performance, source and descriptions of the counterfactual supply side forecast components, the modelled interventions, and sensitivity analysis. 7. **LTWP modelling v2** (10.02.2023)**:** As above, with the addition of sensitivity analysis and international comparisons. 8. **LTWP Supply Modelling (002)** (10.02.2023): Outlines supply modelling approach and assumptions, including the workforce apportioning process, mental health workforce assumptions, counterfactual and improvement assumptions on retention, process of supply side triangulation to examine effect of interventions on workforce gaps.

	9. **LTWP Supply Modelling (clinical professions)** (13.02.2023): As above, with the addition of community and further mental health workforce consideration. 10. **LTWP Supply Modelling – medical components (consultants)** (13.02.2023): Outlines the nature of the NHS medical workforce, the HERMES data set used for derivations of flow and historic flow values and illustrates the triangulation process to optimise the supply and demand gap. 11. **LTWP dental pharmacy combined pack** (07.02.2023): Outlines graphical representations of community pharmacy and NHS primary care dental workforce demand and supply. 12. **LTWP cancer and diagnostics update** ((10.02.2023): Outlines the response of cancer and diagnostic colleagues to modelled growth rates and demand by profession. 13. **Understanding Analysing and Projecting Medical Workforce** (13.02.2023)**:** Outlines the process of the Supply Demand Intervention (SDI) model for the medical workforce, exploring complexity, training, flows to, from, and within the workforce; the counterfactual, interventions to reduce gaps, and the required data improvements. 14. **National strategic model - medical workforce supply components** (13.02.2023)**:** Outlines the medical workforce supply counterfactuals and scenario levers, pathways, and flows. 15. **Medical Supply Impact** (13.02.2023): Outlines and explores the marginal impact of nationally orchestrated or nationally led interventions (such as increasing intake to post graduate training programmes and transition from training to permanently employed constant workforce or reducing final retirement and attrition) on medical supply flows. 16. **HEFT Handbook** (13.02.2023) 17. **HERMES Handbook** (13.02.2023) Both documents summarise the process of development of HEFT and HERMES data respectively, explaining the approach to bridging, cleansing, and summarising the data.
Assumptions	Includes: 1. **Assumptions log HF** (10.02.2023): 2. **HIA assumptions v3 HF review** (10.02.2023): Both documents detail: descriptions of the input/assumption, how it has been used within the model, the data source and relevant calculation/owner, quality rating and description, impact rating and description. There are links to evidence/source, triangulation with other sources, date of last update and when the next is due. Information is also provided on: the model component the input/assumption is applied to, the timeframe, care setting, assumption owner and location in the model/link, staff group/profession applied to, status/sign off and comments, meeting notes or minutes, reference and workstream. 3. **ARRS & nursing interventions assumptions overview** (07.02.2023): sets out the structural and parametric assumptions behind the proposed ARRS and Primary Care Nursing intervention.
Changes	Includes: 1. **Change log** (10.02.2023): 2. **Change log HIA** (10.02.2023) Both logs record the original decision and the changes made by model component, rationale for the change and links to relevant meetings notes/emails.
Retention and leaver rate	Includes: 1. **Retention HIA** (14.02.2023): Details data sources, methodology, and brief scenario analysis of the retention and leaver rates modelling

	2. **Leaver Rate Modelling QA file** (14.02.2023): contains historic data and rates, the scenario points for stretch, moderate, and average as well as their calculations, and overall methodology 3. **Impact of the pandemic on Leaver FTE** (14.02.2023): Analysis to consider the FTE gains across staff groups due to reduced leavers during the pandemic, and whether these gains have been cancelled out due to leaver rates now exceeding pre-pandemic levels. Methodology and counterfactual (if the pandemic had not happened). 4. **Leaver rate CF model 11 Oct 2022** (14.02.2023): Leaver rates by profession for Jul 22 and Mar 22 (used in the model).
Primary Care	Includes: 1. **PC LTWP modelling update – changes (Dec 22 – Feb 23)** (14.02.2023): Outlines the illustrated impact of changes and interventions to reduce the final gap of FTE GPs and better align with the GP Access Recovery Plan. 2. **Uncertainty in LTWP Modelling** (14.02.2023): Outlines the sensitivity analysis of assumptions on the average nett clinical need provided by a GP in Training Grade to Fully Qualified and on the increase in Direct Patient Care (DPC) and GP Nurse supply. 3. **General Practice LTWP Update** (14.02.2023): Presents the counterfactual demand and supply of GPs (Fully Qualified equivalent, ARRS staff and Nurses), the impact of policy proposals and interventions to the end of the time period, and some detail on the proposed interventions (modelled and unmodelled).

Annex D - Log of Meetings and Workshops between NHSEI and THF/REAL

Date	Workshop		THF Attendees
3rd February 2023	Inception Meeting: Review of modelling in the LTWP Discussion		Anita Charlesworth Hiba Sameen Nihar Shembavnekar Nuha Bazeer Laurie Rachet-Jacquet
6th February 2023	Workshop 1: Model review		Hiba Sameen Nihar Shembavnekar Nuha Bazeer Laurie Rachet-Jacquet
8th February 2023	Workshop 2: Model review		Anita Charlesworth Hiba Sameen Nihar Shembavnekar Nuha Bazeer Toby Watt Laurie Rachet-Jacquet Ruth McConkey
9th February 2023	Workshop 3: Documentation Review		Hiba Sameen Nihar Shembavnekar Nuha Bazeer
10th February 2023	Workshop 4: Productivity Modelling		Hiba Sameen Nihar Shembavnekar Nuha Bazeer Laurie Rachet-Jacquet
13th February 2023	Workshop 5: Supply and Policy Options Modelling		Anita Charlesworth Jim Buchan Hiba Sameen Nuha Bazeer Laurie Rachet-Jacquet
16th February 2023	Workshop 6: Primary care, community pharmacy, and dental		Nuha Bazeer Laurie Rachet-Jacquet Toby Watt